PCT

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(54) Title: METHOD FOR ADMISSION CONTROL IN INTERFERENCE–LIMITED CELLULAR RADIO NETWORK

(57) Abstract

The invention relates to a method for admission control in an interference–limited cellular radio network. Admission can be accepted, if there is a sufficient number of free channels whose measured interference level goes below the interference threshold determined for the channel. The interference threshold of the channel is changed adaptively to ensure the best possible quality of the service offered. In case the quality value of the served radio connections is too low, the interference threshold value of the channel is lowered. In case the quality value of the served radio connections is very good, the interference threshold value of the channel is raised.
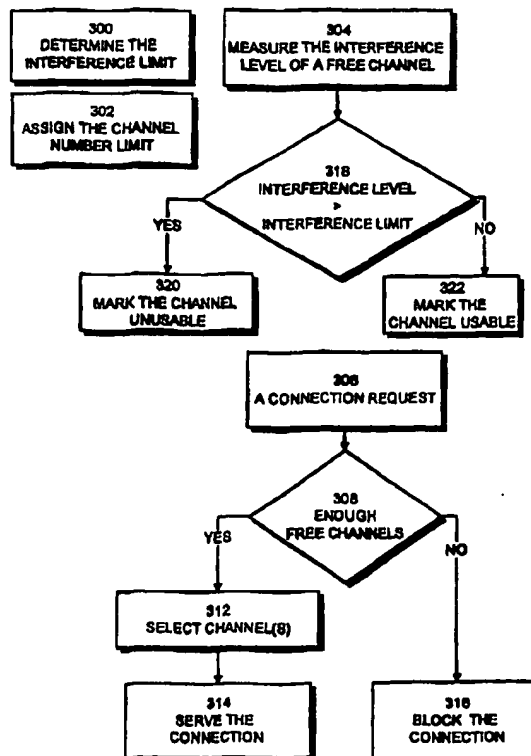
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METHOD FOR ADMISSION CONTROL IN INTERFERENCE-LIMITED CELLULAR RADIO NETWORK

FIELD OF THE INVENTION

The invention relates to a method for admission control in an inter-
5   ference-limited cellular radio network, the cellular radio network comprising a
network part, at least one subscriber terminal and a bidirectional radio con-
nection between the network part and the subscriber terminal, and the radio
connection being at least on one channel, and in the network part are per-
formed

10   determination of the interference threshold of the channel,

measurement of the interference level of at least one free channel,

comparison of the measured interference level of the free channel
with the interference threshold, and decision whether the channel is usable or
unusable.

15 DESCRIPTION OF THE PRIOR ART

In a cellular radio network information is transferred between a net-
work part and a subscriber terminal by transmitting signals. Five different fac-
tors may distort the signal on its way from a transmitter to a receiver: modula-
tor of a transmitter, means of transmission, i.e. radio waves, interference
20 sources, fading, and demodulator of a receiver. The whole formed by these
factors is called a channel. Each base station has a plurality of channels at its
disposal. The channels may be separated from one another by means of time
(TDMA), frequency (FDMA), codes (CDMA) or any combinations of these
methods. So on the channel information is transferred in a signal form. The
25 present invention relates to interference sources. The interference sources
particularly refer to interference of adjacent channels and interference caused
by remote transmitters operating on the same channel.

One purpose of frequency planning is to reduce interference that
transmitters operating on the same channel cause to one another. By fre-
30 quency planning it is determined which frequencies can be used in which cells.
To keep the interference on the channel sufficiently low, the transmitters oper-
ating on the same (or on the adjacent) channel are to be sufficiently far apart.
This is known as a frequency reuse. The distance between transmitter-
receiver pairs operating at the same frequency has to be of a certain length,
35 for instance three times the cell diameter. Various reuse patterns have been

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designed, for instance, the seven-cell reuse pattern. In accordance with these kinds of solutions a new radio connection can always be established, if there is at least one free channel, since the transmitters operating on the same or adjacent channel are so far apart that the interference level is always sufficiently
5   low.

Since the number of cellular radio network users has increased considerably during the past few years, the same frequencies must be reused in cells that are very close to one another. This results from the fact that only a very restricted frequency band is allocated to each network operator. The fre-
10 quency band has to be utilized efficiently, otherwise the network cannot simultaneously hold enough users, and when a new user is trying to establish a connection, it cannot be admitted, the connection is blocked, i.e. no radio connection is allocated to the user.

A cellular radio network where the same frequencies are reused in
15 cells so close to one another that the connection quality is limited by interference caused by other users, not by background noise, is called interference-limited. If interference on the channel is intense, a radio connection can not necessarily be allocated to a new user, since consequently, speech or other payload cannot be transferred reliably, even though the channel itself were
20 free. This has notable drawbacks, since if the channel is allocated for use, the user finds the quality of service provided poor and may even destroy connections of other users. Consequently, some other criterion than just the freedom of the channel has to be found for a connection to be established or to be blocked.

25 BRIEF DESCRIPTION OF THE INVENTION

The aim of the present invention is to provide a method by which the admission control can be implemented effectively, and which simultaneously enables an effective frequency reuse.

This is achieved with a method set forth in the preamble, the
30 method being characterized in that it comprises the steps of

assigning the channel number threshold,

deciding whether the number of free channels below the interference threshold exceeds the channel number threshold, when at least one free channel below the interference threshold is selected and allocated to a new
35 radio connection, or whether the number of free channels below the interfer-

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ence threshold goes below the channel number threshold, when a new radio connection is blocked.

The invention further relates to an interference-limited cellular radio network which comprises a network part, at least one subscriber terminal and
5   a bidirectional radio connection between the network part and the subscriber terminal, and the network part is arranged

to define the interference threshold of the channel,

to measure the interference level of at least one free channel,

to compare the measured interference level of the free channel with
10 the interference threshold of the channel, and to decide whether the channel is usable or unusable.

The system is characterized in that the network part is arranged

to assign the channel number threshold,

to decide whether the number of free channels below the interfer-
15 ence threshold exceeds the channel number threshold, when at least one free channel below the interference threshold is selected and allocated to a new radio connection, or whether the number of free channels below the interfer- ence threshold goes below the channel number threshold, when a new radio connection is blocked.

20   Several advantages are achieved with the method of the invention. It allows efficient definition whether new users can be admitted to the network or not. If the usability of the channel depends on the dynamically varying in- terference level, so the described method both enables the efficient use of ra- dio resources and guarantees an acceptable quality to the user. The method
25 of the invention advantageously realizable, and it is technically simple and effi- cient.

The system according to the invention has the same advantages as those described above in relation to the method. It is obvious that preferred embodiments and detailed embodiments can be combined with one another to
30 provide various combinations in order to achieve the desired technical effi- ciency.

DESCRIPTION OF THE DRAWINGS

In the following the invention will be described in greater detail with reference to the examples in accordance with the attached drawings, in which
35   Figure 1 illustrates an interference-limited cellular radio network,

Figure 2 illustrates by way of example how arrangements according to the invention are carried out in the network part,

Figure 3 illustrates steps of admission control as a flow chart

Figure 4 illustrates steps of determining an interference threshold of 5 a channel as a flow chart

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Figure 1 is examined. Between a network part 100 and a subscriber terminal 102 there is a bidirectional radio connection 104. That part of the network part 100 which actually forms the radio connection 104 is a base station. 10 The network part further comprises, for instance, a base station controller, a mobile services switching centre and a network management system. The base station has a coverage area, i.e. a cell (shown in the figure as a hexagonal area). The radio connection 104 is on the channel. On the channel, there may occur interference caused especially by a base-station-terminal pair op- 15 erating on the same channel in any nearby cell.

Admission control refers to the operations by which the decision is made on the opening or blocking of the radio connection 104. Figure 3 is examined. The method of the invention comprises the following steps:

Determination 300 of an interference threshold of a channel. The 20 interference threshold of the channel refers to the numerical value below which interference is so low that the channel can be made available to a new radio connection 104. If the measured numerical value of interference occurring on the channel exceeds the interference threshold, the channel cannot be made available to a new radio connection 104. During the manufacturing 25 process and/or when the network is being built, a default value is set for the interference threshold. Later on, when the network is already in use, this value is changed dynamically to correspond to the operating conditions, using the method described later in this text, and/or the network operator sets a value for this parameter, for instance, by means of a network management system.

30   Assignment 302 of a channel number threshold. The channel number threshold (1, 2, 3, ... N) refers to a parameter which indicates how many free channels below the interference threshold are needed for a new radio connection 104 to be established. Normally, one channel will suffice to establish a connection. The network operator sets a value for this parameter, for in- 35 stance, by means of a network management system. During the manufacturing process and/or when the network is being built, a default value is set for

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the channel number threshold. If a plurality of free channels is required, the channel allocation can be changed dynamically when interferences on the channel change, and the quality of the radio connection 104 offered can be maintained high. On the other hand, if too many free channels are required,

5   before a new radio connection 104 can be established, then the blocking of radio connections 104 increases, and the user finds the quality of service provided poor.

Measurement 304 of the interference level of at least one free channel. Free channels are periodically or randomly measured for interference

10   level. This is carried out in accordance with the prior art, for instance, with a measuring receiver at a base station.

Comparison of the interference level of the measured free channel with the interference threshold 318 and decision whether the channel is usable 322 or unusable 320. At this step, it is decided whether the interference level

15   of the free channel is sufficiently low, in order that it could be made available to a new radio connection 104.

Decision whether the number of free channels below the interference threshold exceeds the channel number threshold, when at least one free channel below the interference threshold is selected 312 and allocated 314 to

20   a new radio connection 104, or whether the number of free channels below the interference threshold goes below the channel number threshold, when a new radio connection 104 is blocked 316.

The determination of the interference threshold of the channel is a significant part of the invention. Figure 4 is examined. The determination is

25   carried out by following steps:

Decision on which quality value of served radio connections correlates to which interference threshold of the channel 400. This means that it is indicated in some specific form, for instance, as a table or a mathematical formula, which quality value correlates to which interference threshold. The net-

30   work operator determines this correlation, for instance, by means of the network management system. During the manufacturing process and/or when the network is being built, some specific default value correlation is determined.

Monitoring 402 and adding to the statistics 404 the quality value of radio connections 104 served by the network part. This means that an indica-

35   tor is provided for the quality of radio connections 104, on the basis of which indicator the quality of each served radio connection 104 is assessed. A qual-

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ity indicator is; for instance, an average number of defective bits per each transmitted information packet (for instance a frame), the number of prematurely interrupted radio connections 104, or some other known indicator. In packet transmission, for instance, when data is transferred in packets, a qual-

5 ity indicator may be, for instance, the ratio of the negotiated bit rate to the actual bit rate, the bit rate, the ACK/NACK ratio (i.e. the relationship between packets received without defects and packets retransmitted), or some other known indicator. It must be emphasized that in view of the invention, it is not essential which indicator is used, but how it is used in the described method of

10 determining the interference threshold of the channel. The measured quality of each served radio connection 104 or some of the served radio connections 104 is added to the statistics.

Changing 406 of the interference threshold value of the channel. Periodically, randomly or at request of a network element, the network part

15 100 updates the interference threshold value of the channel in accordance with the following logic:

If the quality value of the served radio connections 104 is too low, the interference threshold value of the channel is lowered 408. This means that utilizing the above-mentioned correlation, according to which the quality

20 value in the statistics of the served radio connections 104 correlates to an interference threshold value of the channel, the interference threshold value is changed to have a lower value. As a consequence the quality of served connections 104 will improve in the long run.

If the quality value of served connections 104 is very good, the in-

25 terference threshold value of the channel is raised 410. Then bit errors in the connections increase, but the connections remain, however, sufficiently good, since the number of defective bits is still sufficiently low to enable error correction. On the other hand, the quality of service improves, since the number of blocked radio connections 104 diminishes. The interference threshold value is

30 not to be changed frequently without ground. So a certain range of variation for a quality factor can be regarded as reasonably good quality. As long as the quality remains within this range, the interference threshold value is not changed. In this way the unnecessary unstability of the system is avoided.

In one embodiment the interference threshold value of the channel

35 and/or the channel number threshold value depend on the type of service transmitted in the radio connection 104. For instance, one free low interfer-

ence channel is sufficient to speech services. For a video call, in which a moving picture is transmitted, the channel number threshold value may be much higher, for instance eight. On the other hand, when packet transmission is used, for instance, for data transmission, the interference threshold value

5   may differ greatly from the interference threshold used for speech services.

The interference threshold values can be adapted in such a way that adaptation steps are the same for all services, but the difference of the threshold values of various services equals to the difference of the C/I targets. So for example, for speech the C/I value is 15 dB and for data 10 dB. Thus the

10 interference threshold value for speech is -100 dBm and for data -105 dBm. Now that the interference threshold value of a specific service is to be changed, simultaneously the interference threshold value of other services is changed with an equal adaptation step.

In one embodiment the channel performs frequency hopping. In this

15 case the channel refers to a hopping sequence, in other words, data of the same user is transmitted in the radio connection 104 by changing a frequency and/or a time slot within different frames. Various frequency hopping types comprise cyclic frequency hopping and random frequency hopping. The cyclic frequency hopping is performed constantly along a specific short hopping se-

20 quence. In the random frequency hopping, hopping is performed in accordance with a long pseudo-random sequence, i.e. various frequencies and/or time slots are used in a random order.

In the cyclic frequency hopping, the hopping sequence is equated with the channel and interference is measured from channels included in the

25 sequence. In the admission control a new radio connection is admitted if there is a sufficient number of sufficiently good hopping sequences available. An indicator showing the degree of quality is, for instance, one or some of the following: the average interference of the sequence, the maximum interference of the sequence, a sufficient number of sequence channels with sufficiently

30 low interference.

In the random frequency hopping, the interference level of the channel is determined by measuring the interference level of a channel set and by determining the average interference level of the channel. A channel set refers to some specific channels or all channels. In the admission control a

35 new radio connection is admitted if the average interference is sufficiently low, and a required number of transmitter-receiver pairs is available at the base

station. So, in this case the channel number threshold is not used, since all channels have the same interference, on average.

It is obvious to one skilled in the art that the performance order of the described method steps may vary, so for instance, the steps 300 and 302

5   of Figure 3 can be performed at almost any stage.

An arrangement in a cellular radio network according to the described method is easy to implement. Relatively small modifications are needed for the network part 100. The network part 100 is arranged

to define the interference threshold of the channel,

10   to assign the channel number threshold,

to measure the interference level of at least one free channel,

to compare the measured interference level of the free channel with the interference threshold of the channel, and to decide whether the channel is usable or unusable,

15   to decide whether the number of free channels below the interference threshold exceeds the channel number threshold, when at least one free channel below the interference threshold is selected and allocated to a new radio connection 104, or whether the number of free channels below the interference threshold goes below the channel number threshold, when a new

20   radio connection 104 is blocked.

The network part 100 is arranged to define the interference threshold of the channel to the effect that the network part 100 is arranged

to decide which quality value of the served radio connections 104 correlates to which interference threshold value of the channel,

25   to monitor and add to the statistics the quality value of the radio connections 104 served by the network part 100,

to change the interference threshold value of the channel:

if the quality value of the served radio connections 104 is too low, the interference threshold value of the channel is lowered,

30   if the quality value of the served radio connections 104 is very good, the interference threshold value of the channel is raised.

In one embodiment the network part 100 is arranged to determine the interference threshold value of the channel and/or the channel number threshold depending on the quality of service transmitted in the radio connec-

35   tion 104.

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In one embodiment the network part 100 comprises a frequency hopping unit 214 which enables cyclic or random hopping. In the latter case the network part 100 is arranged to measure the interference level of a channel set and to form the average interference level of a channel.

5   Figure 2 is examined, in which it is described by way of example how the network part 100 is arranged to perform the necessary handling. The network part comprises a base station 210, a base station controller 200, a mobile services switching centre 220, and a network management system 220. The mobile services switching centre 220 communicates with the base

10   station controller 200. The base station controller 200 communicates with the base station 210. The base station controller 200 comprises a group switching network 202, a transcoder 204 and a control unit 206. The group switching network 202 is used to switch speech and data, and to connect signalling circuits. The transcoder 204 converts the different digital coding modes of

15   speech, used between the public telephone network and the mobile network, compatible with each other. The control unit 206 performs call control, mobility management, collecting of statistical data, and signalling. The base station 210 comprises a frame unit 212, a frequency hopping unit 214, a carrier unit 216 and an antenna 218. In the frame unit 212 are performed channel coding,

20   channel interleaving, data encrypting and burst forming. In the frequency hopping unit 214 is performed potential frequency hopping onto the baseband wave. In the carrier unit 216 are performed modulation and analogue-to-digital conversion of the transmitted signal. By means of the network management system 230 various operations of the cellular radio network are used, con-

25   trolled and maintained. The network operator adjusts through the network management system 230 different parameters of the cellular radio network and thus controls its operation. The main function of the mobile services switching centre 220 is call control.

The base station controller 200 establishes a connection with a

30   subscriber terminal 102 by requesting the base station 210 to transmit a message to the subscriber terminal 102 for call 104 establishment. Correspondingly, the subscriber terminal 102 responds to the call 104 establishment message. The simplest way to implement the invention is to convert the arrangements required by the network part 100 into software. Then the software can

35   be installed, for instance, in the memory of the control part 206 of the base station controller 200. The network operator changes the necessary parameter

10

values through the network management system 230 which communicates with the base station controller 210, for instance, via the mobile services switching centre 220. On the other hand, the arrangement can be implemented with general or signal processors, or with separate logic. The division

5   of operations between the base station controller 200 and the base station 210 can also be performed in some other way in the spirit of the invention. Any other part of the network part 100, for instance, the mobile services switching centre 220, can also be arranged to perform the operation required by the invention in accordance with the described principles.

10   Even though the invention has been described in the above with reference to an example in accordance with the attached drawings, it is obvious that the invention is not restricted thereto, but it can be modified in a variety of ways within the scope of the inventive idea disclosed in the appended claims.

CLAIMS

1. A method for admission control in an interference-limited cellular radio network, the cellular radio network comprising a network part (100), at least one subscriber terminal (102), and a bidirectional radio connection (104)

5   between the network part (100) and the subscriber terminal (102), and the radio connection (104) being at least in one channel, and in the network part (100) are performed

determination (300) of the interference threshold of the channel, .

measurement (304) of the interference level of at least one free

10   channel,

comparison (318) of the measured interference level of the free channel with the interference threshold of the channel, and decision whether the channel is usable (322) or unusable (320),

c h a r a c t e r i z e d   in that the method comprises the steps of

15   assigning (302) the channel number threshold,

deciding (308) whether the number of free channels below the interference threshold exceeds the channel number threshold, when at least one free channel below the interference threshold is selected (312) and allocated (314) to a new radio connection, or whether the number of free channels be-

20   low the interference threshold goes below the channel number threshold, when a new radio connection (104) is blocked (316).

2. A method as claimed in claim 1, c h a r a c t e r i z e d   in that the determination (300) of the interference threshold of the channels comprises the steps of

25   deciding which quality value of served radio connections (104) correlates to which interference threshold value (400) of the channel,

monitoring (402), and adding to the statistics (404) the quality value of radio connections (104) served by the network part,

changing (406) the interference threshold value of the channel:

30   if the quality value of the served radio connections (104) is too low, the interference threshold value of the channel is lowered (408),

if the quality value of the served radio connections (104) is very good, the interference threshold value of the channel is

35   raised (410).

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3. A-method as claimed in any one of preceding claims, c h a r a c -
t e r i z e d in that the interference threshold value of the channel depends on
the quality of service transmitted in the radio connection (104).

4. A method as claimed in any one of preceding claims, c h a r a c -
5 t e r i z e d in that the channel number threshold depends on the quality of
service transmitted in the radio connection (104).

5. A method as claimed in any one of preceding claims, c h a r a c -
t e r i z e d in that the channel performs frequency hopping.

6. A method as claimed in any one of preceding claims, c h a r a c -
10 t e r i z e d in that in the cyclic frequency hopping, the hopping sequence is
equated with the channel.

7. A method as claimed in any one of preceding claims 1 to 5,
c h a r a c t e r i z e d in that in the random frequency hopping, the interfer-
ence level of the channel is determined by measuring the interference level of
15 a channel set and by determining the average interference level of the chan-
nel.

8. An interference-limited cellular radio network comprising a net-
work part (100), at least one subscriber terminal (102) and a bidirectional radio
connection (104) between the network part (100) and the subscriber terminal
20 (102), and the radio connection (104) being on at least one channel, and the
network part (100) is arranged

to determine the interference threshold of the channel,

to measure the interference level of at least one free channel,

to compare the measured interference level of the channel with the
25 interference threshold of the channel and to decide whether the channel is us-
able or unusable,

c h a r a c t e r i z e d in that the network part (100) is arranged

to assign the channel number threshold,

to decide whether the number of free channels below the interfer-
30 ence threshold exceeds the channel number threshold, when at least one free
channel below the interference threshold is selected and allocated to a new
radio connection (104), or whether the number of free channels below the in-
terference threshold goes below the channel number threshold, when a new
radio connection (104) is blocked.

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9. A system as claimed in claim 8, **c h a r a c t e r i z e d** in that the network part (100) is arranged to determine the interference threshold of the channel in such a way that the network part is arranged

to determine which quality value of the served radio connections

5   (104) correlates to which interference threshold value of the channel,

to monitor and add to the statistics the quality value of the radio connections (104) served by the network part (100),

to change the interference threshold value of the channel:

if the quality value of the served radio connections (104)

10   is too low, the interference threshold value of the channel is lowered,

if the quality value of the served radio connections (104) is very good, the interference threshold value of the channel is raised.

15   10. A system as claimed in any one of preceding claims 8 to 9, **c h a r a c t e r i z e d** in that the network part (100) is arranged to determine the interference threshold value of the channel depending on the quality of service transmitted in the radio connection (104).

11. A system as claimed in any one of preceding claims 8 to 10,

20 **c h a r a c t e r i z e d** in that the network part (100) is arranged to determine the channel number threshold value depending on the quality of service transmitted in the radio connection (104).

12. A system as claimed in any one of claims 8 to 11, **c h a r a c -
t e r i z e d** in that the network part (100) comprises a frequency hopping unit

25   (214).

13. A system as claimed in any one of preceding claims 8 to 12, **c h a r a c t e r i z e d** in that the network part (100) comprises a frequency hopping unit (214) that provides cyclic hopping.

14. A system as claimed in any one of preceding claims 8 to 12,

30 **c h a r a c t e r i z e d** in that the network part (100) comprises a frequency hopping unit (214) that provides random hopping, and that the network part (100) is arranged to measure the interference level of a channel set and to determine the average interference level of the channel.
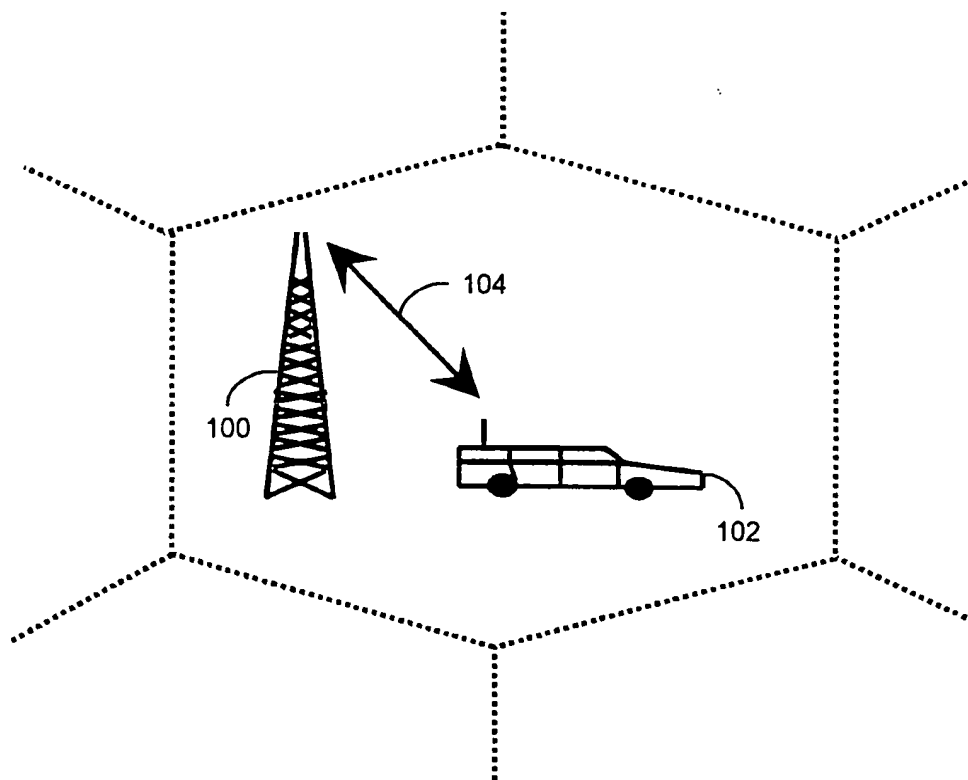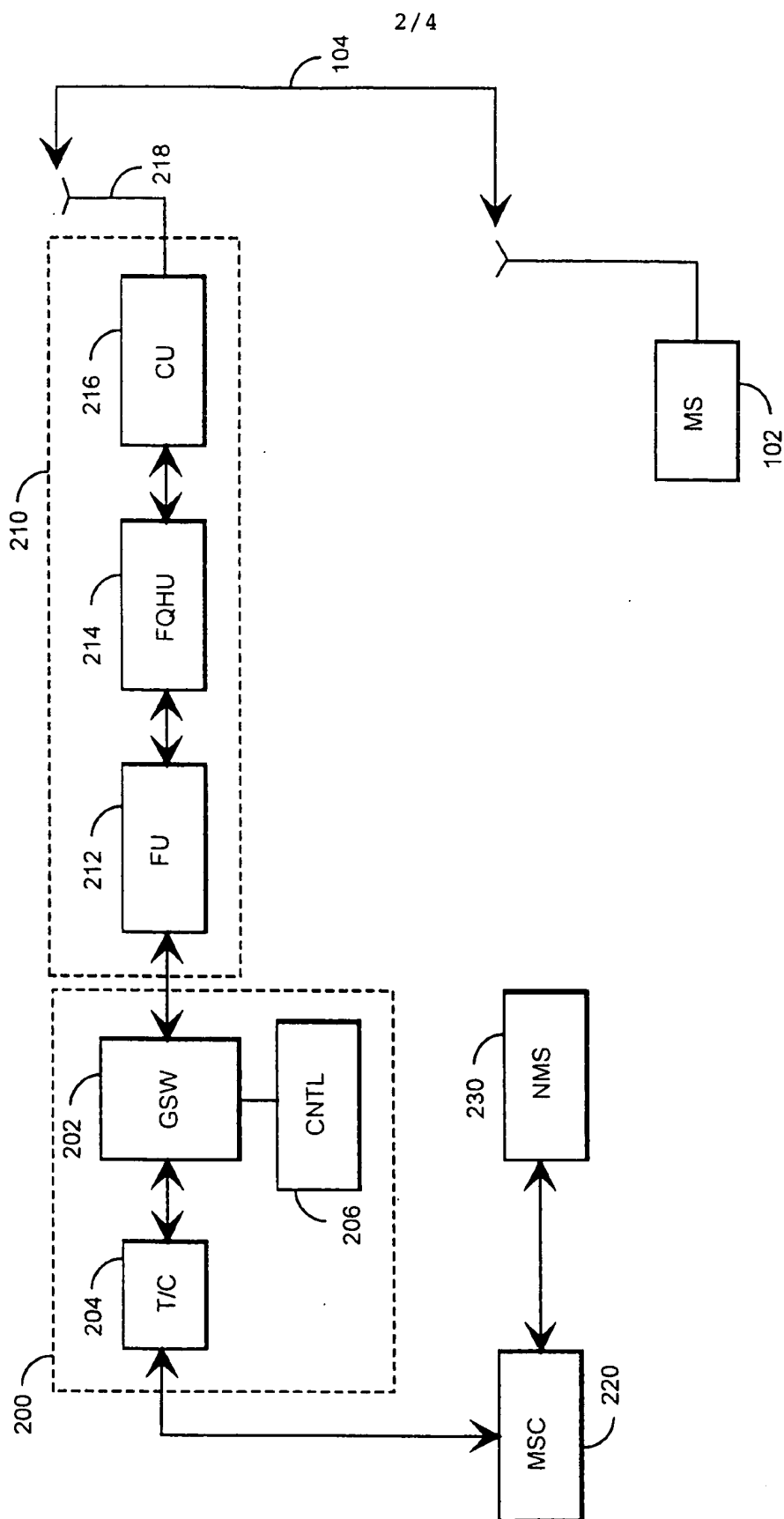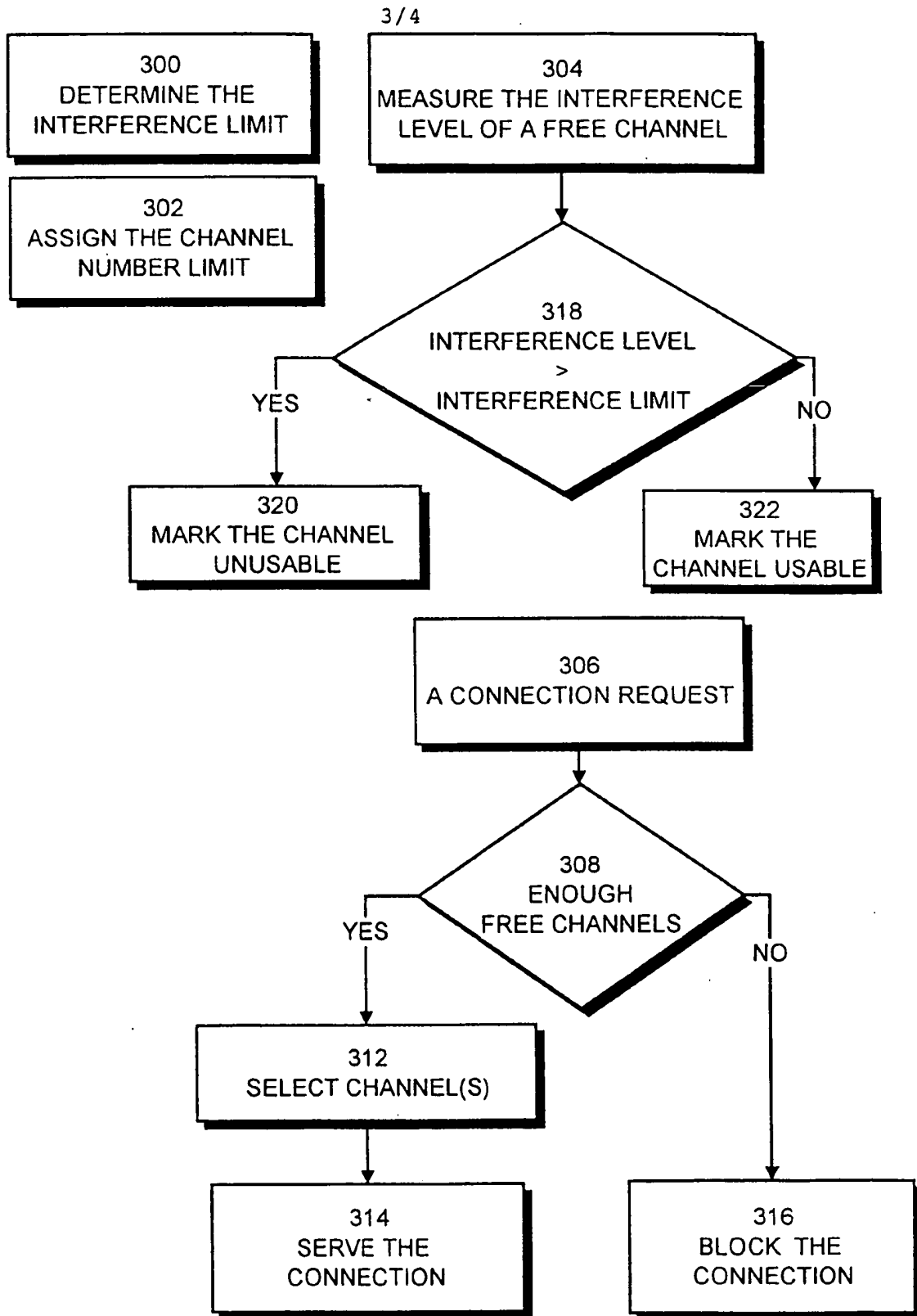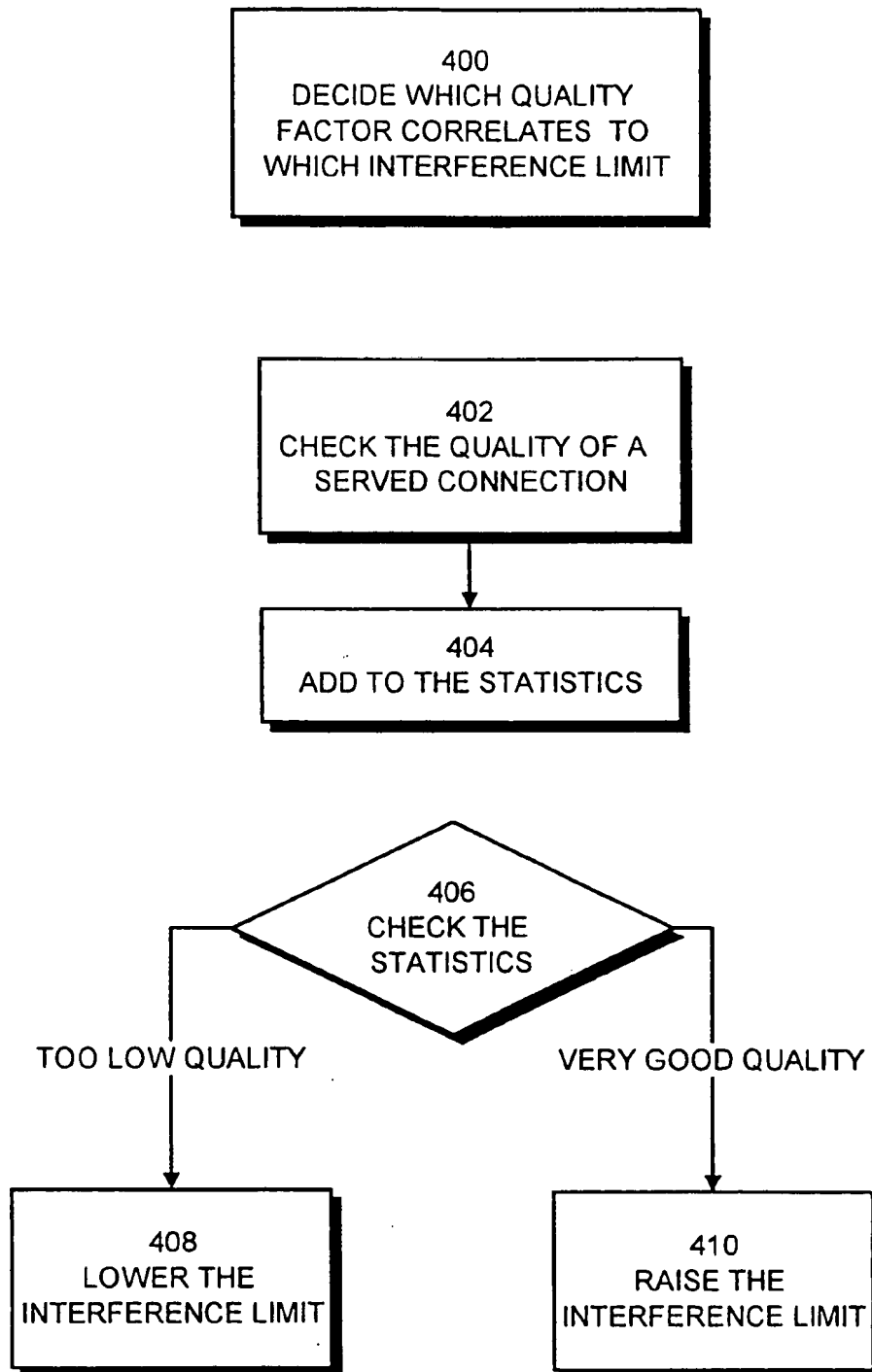
Fig 1

Fig 2

Fig 3

Fig 4

INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI 97/00808

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H04Q 7/38

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: H04B, H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0716555 A2 (NEC CORPORATION), 12 June 1996 (12.06.96), claims 1,5,12, abstract	1-14
X	US 5101503 A (YUKITSUNA FURUYA), 31 March 1992 (31.03.92), column 2, line 7 - line 45, claim 1	1-14
X	US 5239676 A (LEO STRAWCZYNSKI ET AL), 24 August 1993 (24.08.93), column 2, line 43 - column 3, line 8, claims 3,4, abstract	1-14
A	US 5377221 A (PETER J. MUNDAY ET AL), 27 December 1994 (27.12.94), abstract	1-14

[X] Further documents are listed in the continuation of Box C.   [X] See patent family annex.

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C (Continuation).   DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 9308655 A1 (MOTOROLA, INC.), 29 April 1993 (29.04.93), page 2, line 3 - line 18, claims 2,7	1-14
A	WO 9604722 A2 (NOKIA TELECOMMUNICATIONS OY), 15 February 1996 (15.02.96), claims 1,2, abstract	1-14

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